

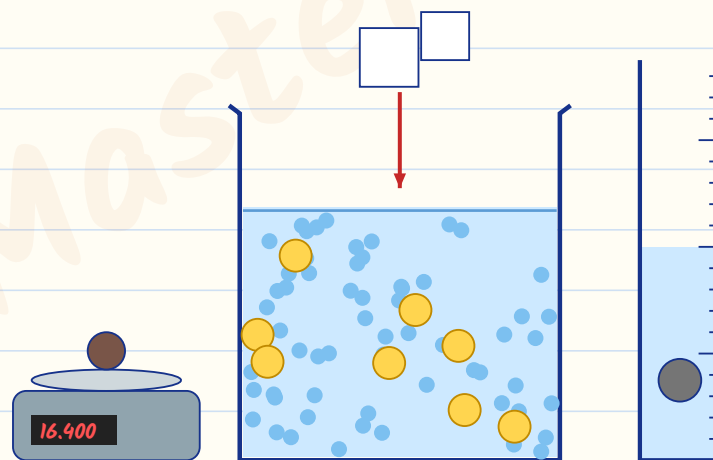
## CLASS 8 | SCIENCE | CURIOSITY (NCERT)

# Chapter 9

## The Amazing World of Solutes, Solvents and Solutions

*Detailed Handwritten-Style Notes*

*with activities, diagrams, examples, fun Q&A and solved NCERT exercise*



### Inside:

- \* Uniform and non-uniform mixtures; solute, solvent, solution
- \* Saturated / unsaturated, concentration, solubility & temperature
- \* Solubility of gases and why fish need cold(er) water
- \* Density, float & sink, measuring mass and volume (with activities)
- \* Effect of temperature and pressure on density; why ice floats
- \* Fun Q&A after every topic + full NCERT exercise solved + practice sheet

## Chapter at a Glance

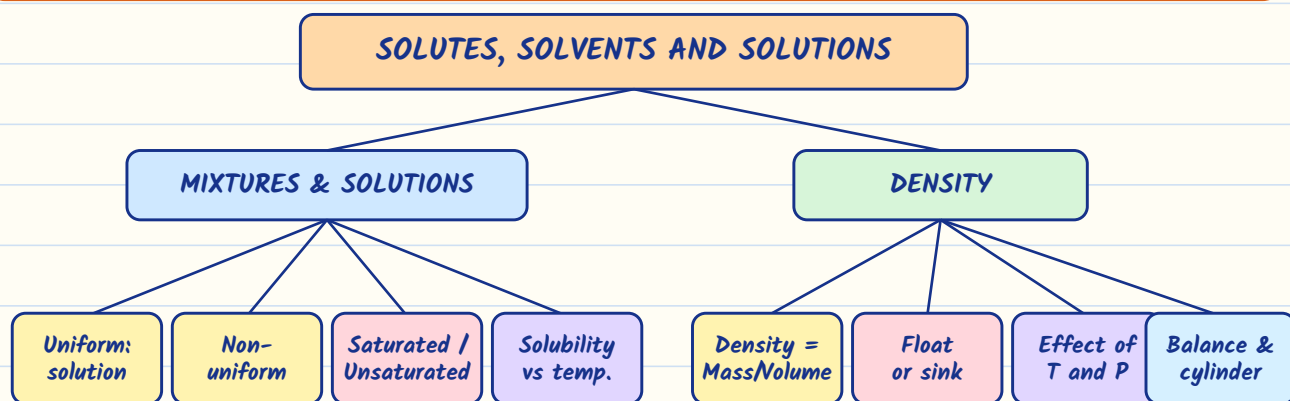


Fig. 1: Concept map of the chapter

### Quick intro - ORS ka funda

Remember the **ORS** (Oral Rehydration Solution) you made in Grade 6? Every sip tastes exactly the same - not salty in one sip and sweet in the next. That is because sugar and salt get **evenly distributed** in water. Such an even mixture is a **solution**.

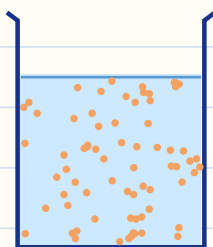
In this chapter we learn **how things mix** (solute, solvents, solutions) and **how heavy a material is for its size** (density), which also tells us why some things float and others sink.

### Probe and Ponder - quick answers

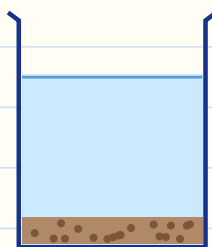
- **What is happening in the picture?** People are collecting salt on the seashore - it looks like the famous **Dandi Salt March (1930)**. Salt is obtained from sea water: when the water evaporates, the dissolved salt is left behind.
- **Too much sugar in tea - it stops dissolving. Fix?** The tea has become **saturated** at that temperature. **Heat it** (solubility of solids rises with temperature) or **add more tea/water** (more solvent) and stir.
- **Why do sugar and salt dissolve in water but not oil? Why is water a good solvent?** Water can dissolve a very large number of substances, so it is called a versatile solvent; oil cannot mix with sugar or salt particles. (The deeper reason - polar and non-polar liquids - comes in higher classes.)
- **Why are water bottles tall and cylindrical, not spherical?** A cylinder is easy to hold, stack and pack in a box with no wasted space and it does not roll away like a sphere.

## Uniform and Non-uniform Mixtures

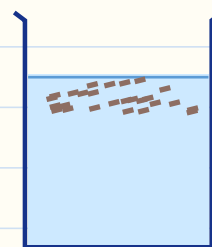
When you mix two or more substances, you get a **mixture**. Look carefully at how evenly the parts are spread.



Salt + water  
**UNIFORM (solution)**



Sand + water  
**NON-UNIFORM (sand sinks)**



Sawdust + water  
**NON-UNIFORM (floats)**

Fig. 2: Salt dissolves evenly; sand and sawdust do not

| Point                         | Uniform mixture (SOLUTION)                                 | Non-uniform mixture                                       |
|-------------------------------|------------------------------------------------------------|-----------------------------------------------------------|
| Distribution                  | Components are <b>evenly</b> spread throughout             | Components are <b>not</b> evenly spread                   |
| Can you see parts separately? | <b>No</b> - looks like one substance                       | <b>Yes</b> - with naked eye or a magnifying device        |
| Examples                      | Salt in water, sugar in water, ORS, air (mixture of gases) | Sand in water, chalk powder in water, sawdust in water    |
| Behaviour on standing         | Stays the same - nothing settles                           | Sand <b>sinks</b> , sawdust <b>floats</b> , chalk settles |

### Remember

- **Uniform mixtures are called solutions.** Every sip of a solution has the same composition.
- The mixture of gases in the atmosphere is also a **uniform mixture**; gases dissolved evenly in water also form a uniform mixture.

## 9.1 What Are Solute, Solvent and Solution?

### Definitions

- **Solution:** a **uniform mixture** of two or more substances.
- **Solute:** the substance that **dissolves** (for a solid mixed in a liquid, the solid is the solute).
- **Solvent:** the substance in which the solute dissolves (the liquid is the solvent).

Solute + Solvent → Solution

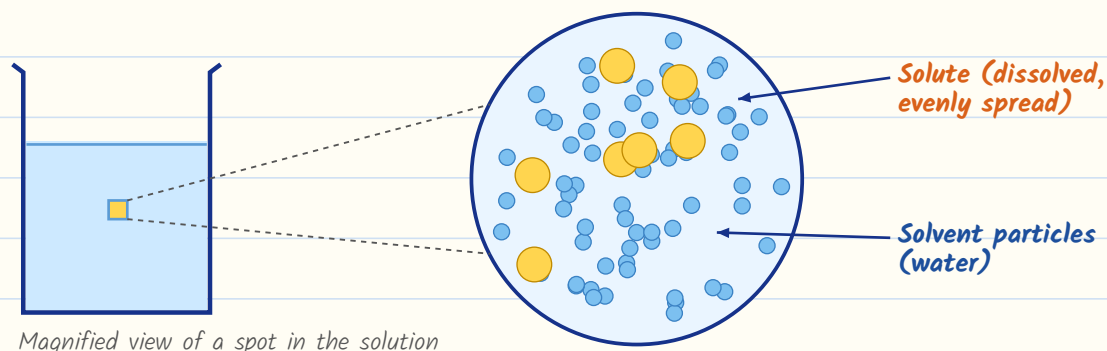


Fig. 3: Magnified picture of a solute evenly distributed in a solvent

| Solution                                                    | Solute                                      | Solvent                                    |
|-------------------------------------------------------------|---------------------------------------------|--------------------------------------------|
| Salt in water                                               | Salt (solid)                                | Water (liquid)                             |
| Sugar in water (sharbat, ORS, tea)                          | Sugar (and salt in ORS)                     | Water                                      |
| Chashni (sugar syrup) of gulab jamun                        | Sugar (large amount!)                       | Water (small amount)                       |
| Two liquids mixed (e.g. a little vinegar in a lot of water) | The liquid present in <b>smaller</b> amount | The liquid present in <b>larger</b> amount |

**Ever heard of... Chashni!**

The sugar syrup of gulab jamun has a **large amount of sugar** and only a **small amount of water**. Still, the water is called the solvent and the sugar the solute, because a solid dissolving in a liquid always treats the solid as solute. The "smaller amount = solute" rule is used only when **both are liquids**.

**Kuch Mazedaar Questions**

**Q1.** Rahul stirs 2 spoons of sugar in a glass of water. Name the solute, the solvent and the solution.

**Ans.** Solute = **sugar**; solvent = **water**; solution = **sugar solution** (sugar water).

**Q2.** Is a mixture of chalk powder and water a solution? Why or why not?

**Ans.** No. Chalk does not spread evenly - it settles down and can be seen separately, so it is a **non-uniform mixture**.

**Q3.** 10 mL of liquid A is mixed with 90 mL of liquid B to make a solution. Which is the solute?

**Ans.** For two liquids, the one in **smaller amount** is the solute: **liquid A** (10 mL); liquid B is the solvent.

**Q4.** Is air a solution?

**Ans.** Air is a **uniform mixture of gases**, so we can treat it as a solution (the NCERT exercise confirms the atmosphere is a uniform mixture).

## 9.2 How Much Solute Can a Fixed Amount of Solvent Dissolve?

### Activity 9.1 - keep adding salt

Let us investigate

- Fill a clean glass tumbler **half** with water. Add **one spoon of salt** and stir until it dissolves.
- Keep adding salt **one spoon at a time**, stirring each time. Note (Table 9.1) how many spoons dissolve.
- After some spoons, the extra salt **stops dissolving** and settles at the bottom. The water has reached its **limit**.

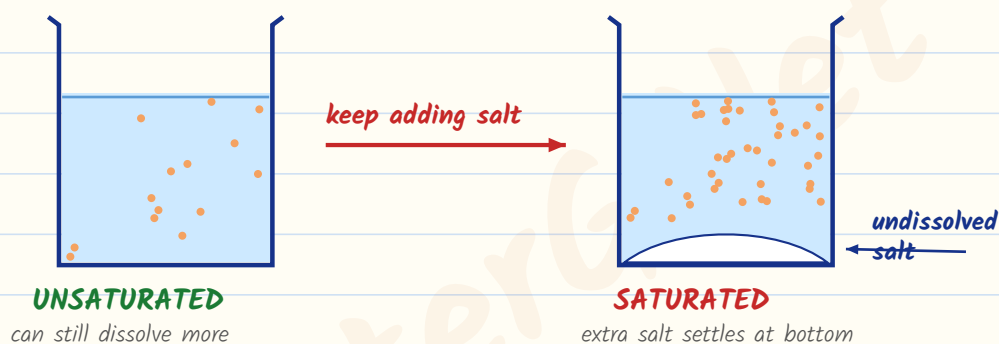


Fig. 4: Unsaturated and saturated solutions

| Term                         | Meaning                                                                                                          | Everyday example                             |
|------------------------------|------------------------------------------------------------------------------------------------------------------|----------------------------------------------|
| <b>Unsaturated solution</b>  | More solute <b>can</b> still be dissolved at that temperature                                                    | First few spoons of sugar in tea             |
| <b>Saturated solution</b>    | No more solute dissolves at that temperature; extra settles at the bottom                                        | Tea so sweet that sugar lies at the bottom   |
| <b>Concentration</b>         | Amount of solute present in a fixed quantity of solution (or solvent)                                            | 2 spoons vs 4 spoons sugar in a cup          |
| <b>Dilute solution</b>       | Contains <b>less</b> solute (relative term)                                                                      | Light sharbat                                |
| <b>Concentrated solution</b> | Contains <b>more</b> solute (relative term)                                                                      | Very sweet sharbat / chashni                 |
| <b>Solubility</b>            | Maximum amount of solute that dissolves in a fixed quantity (e.g. 100 mL) of solvent at a particular temperature | Salt dissolves up to a limit in 100 mL water |

**Dilute and concentrated are RELATIVE terms**

Dissolving one spoon of salt gives a solution that is **dilute compared to** the one with two or more spoons - but that second one is only "more concentrated" relative to the first.

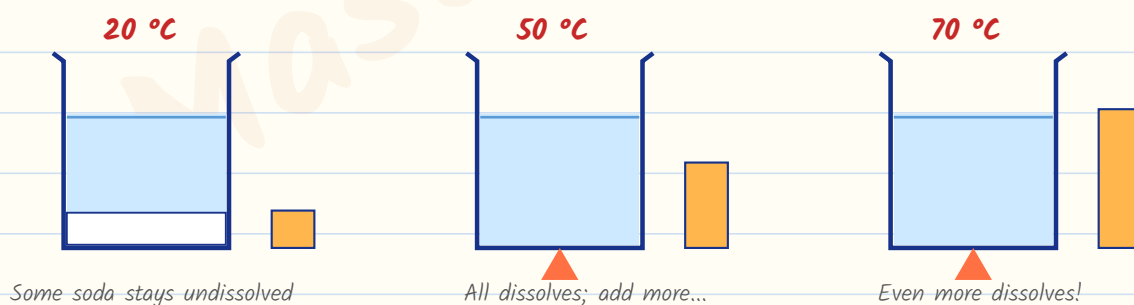
**Reflect (NCERT):** which is more concentrated - 2 spoons in 100 mL or 4 spoons in 50 mL of water?

**Answer:** 2 spoons per 100 mL = 0.02 spoon per mL; 4 spoons per 50 mL = 0.08 spoon per mL.  
So **4 spoons in 50 mL** is the more concentrated solution.

**9.2.1 Effect of Temperature on Solubility****Activity 9.2 - baking soda at 20, 50 and 70 degrees (demonstration)****Safety first!**

Be careful while using the heating device (spirit lamp / burner). This is a **demonstration activity** - do it with your teacher.

- Take about **50 mL water** in a beaker, note its temperature (say 20 °C). Add **baking soda** (sodium hydrogen carbonate) bit by bit, stirring, until some remains undissolved.
- Heat to **50 °C** while stirring: the undissolved baking soda **dissolves**. Add more until some is left again.
- Heat to **70 °C**: the undissolved baking soda **dissolves again**.



**Orange bar = maximum baking soda that dissolves (grows with temperature)**

Fig. 5: More baking soda dissolves as the temperature rises

**Conclusion**

- Water at 70 °C dissolves more baking soda than at 50 °C, and at 20 °C it dissolves even less.
- For **most solids**, solubility **increases** with temperature.
- A **saturated solution** at one temperature behaves like an **unsaturated** solution if the temperature is raised.

**Real-life links**

- Sugar dissolves faster and in larger amounts in **hot tea/milk** than in cold water.
- If tea turns "too sweet to dissolve", warming it or adding more tea fixes the problem (answer to the Probe and Ponder question).
- Apparatus used: laboratory stand, thermometer, glass rod, beaker, wire gauze, tripod stand, spirit lamp.

**Our scientific heritage**

**Water** has been the main solvent for preparing medicines in **Ayurveda, Siddha** and other traditional Indian systems. Drug formulations were also made using **hydro-alcoholic extracts** of herbs, and **oils, ghee, milk** and other substances were used as solvents for medicinal preparations.

**Be a scientist - Asima Chatterjee**

Dr **Asima Chatterjee** developed **anti-epileptic and anti-malarial drugs** from medicinal plants, using solvents and solutions to **extract and isolate** useful compounds. She was the **second Indian woman to earn a Doctorate of Science** (after Janaki Ammal), the **first woman to receive the Shanti Swarup Bhatnagar Award** in chemical science, and was honoured with the **Padma Bhushan**.

**Dekhe Kya Seekha Tumne? - Solutions and solubility**

**Q1. A student adds salt to water and notices some salt settling at the bottom even after stirring. What kind of solution is it? What can she do to dissolve it?**

**Ans.** It is a **saturated solution** at that temperature. She can **heat** the solution or **add more water** to dissolve the remaining salt.

**Q2. What is solubility? Does it stay the same at all temperatures?**

**Ans.** Solubility is the maximum amount of solute that dissolves in a fixed quantity of solvent at a particular temperature. It **changes with temperature** (for most solids it increases when heated).

**Q3. Which is more dilute: Solution X (1 spoon sugar in 200 mL) or Solution Y (1 spoon sugar in 100 mL)?**

**Ans.** X is more dilute (same sugar in more water). Y is more concentrated.

**Q4. Can a dilute solution be saturated?**

**Ans.** Yes, possibly - if the solute has a very low solubility, even a small amount makes the solution saturated. "Dilute/concentrated" and "saturated/unsaturated" are different ideas.

**Q5. Why is the baking soda experiment called a demonstration activity?**

**Ans.** It uses a heating device, so a teacher should do or supervise it for safety.

### 9.3 Solubility of Gases

- Many gases (including **oxygen**) dissolve in water, but only to a **small extent**. Even these tiny amounts of **dissolved oxygen** keep all aquatic life alive - plants, fishes and other organisms.
- Gases dissolve **evenly** in water, so the mixture of gases in water is a **uniform mixture**.

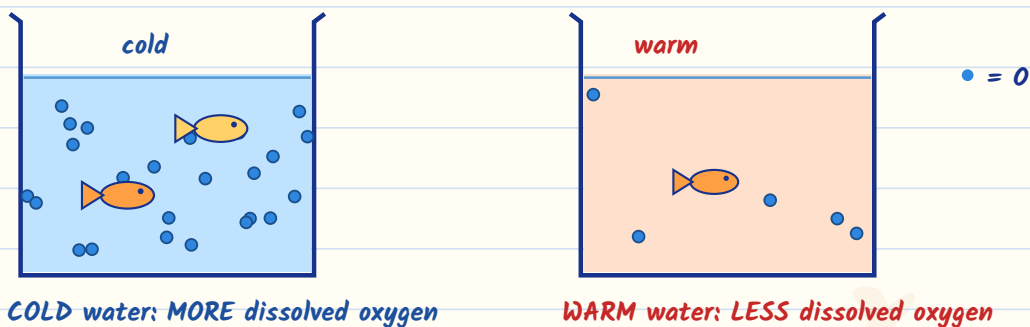


Fig. 6: Cold water holds more dissolved oxygen than warm water

#### Temperature rule for gases

Solubility of **gases** generally **DEcreases** when temperature **increases**. More oxygen dissolves in **cold** water; when water warms up, the dissolved oxygen **decreases**.

|                                  | Solids in liquids                     | Gases in liquids                                                  |
|----------------------------------|---------------------------------------|-------------------------------------------------------------------|
| Effect of increasing temperature | Solubility generally <b>increases</b> | Solubility generally <b>decreases</b>                             |
| Example                          | More sugar dissolves in hot tea       | Less oxygen in a warm pond; warm soft drink loses its fizz faster |
| Why it matters                   | Making syrups, solutions, medicines   | Fish may struggle in very warm water                              |

#### Types of mixtures - the full picture

- Uniform mixtures = solutions:** components are not visible separately.
- Non-uniform mixtures:** components can be seen with the naked eye or a magnifying device.
- In some non-uniform mixtures, one component **floats** (sawdust in water) while another **sinks** (sand in water). Why? That is where **density** comes in!

#### Kuch Mazedaar Questions - Gases

**Q1. Why do fish gasp near the surface of a pond on a very hot summer day?**

**Ans.** Warm water dissolves **less oxygen**, so less oxygen is available for the fish.

**Q2. Why is cold water better than warm water for dissolving oxygen for aquatic life?**

**Ans.** The solubility of gases decreases with temperature, so cold water can hold more dissolved oxygen.

**Q3. Is oxygen very soluble in water?**

**Ans.** No, it dissolves only to a **small extent**, but even that small amount is enough to sustain aquatic life.

## 9.4 Why Do Objects Float or Sink in Water?

- While washing rice, **husk floats** but **rice sinks**. **Oil floats** on water. A **stone sinks**.
- Generally, objects that **float** are "lighter" than the liquid and those that **sink** are "heavier" than the liquid.
- A wooden stick and an iron rod may be the same size, yet iron feels heavier. This special property that tells how heavy a material is for its size is called **density**.

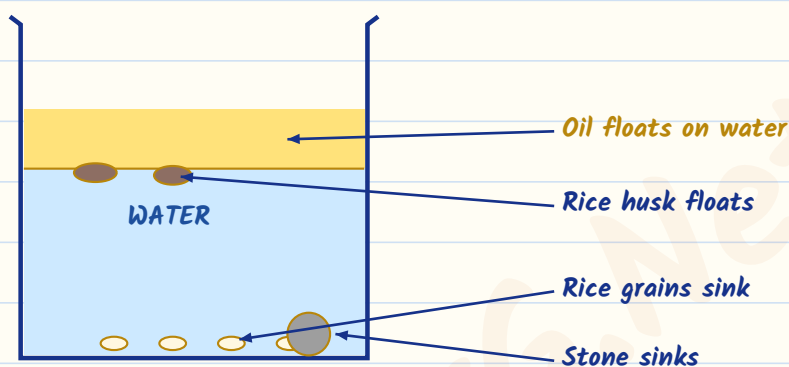


Fig. 7: Floating and sinking in water

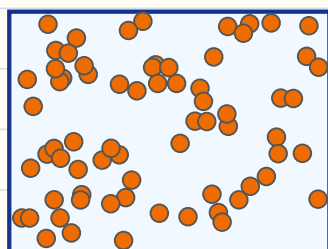
### Note

The density of a substance is **not the only factor** that decides whether it floats or sinks in a liquid. (A big steel ship floats because of its shape - you will learn this later.)

## 9.5 What Is Density?

### Understanding density with everyday examples

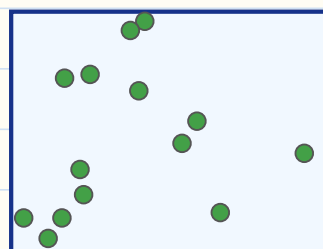
- A **crowded bus** = **high density** of people; the same bus with a few people = **low density**.
- A **dense forest** has trees close together; a forest with trees far apart is **less dense**.



**HIGH density**

many particles in the same volume

crowded bus  
vs half-empty  
same box  
= same  
volume



**LOW density**

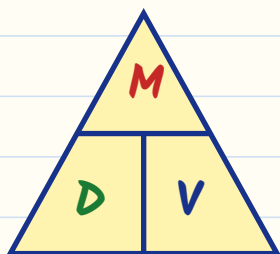
few particles in the same volume

Fig. 8: Same volume, different number of particles - density is different

**DENSITY - definition and formula**

Matter is anything that has **mass** and occupies space (**volume**). **Density** is the **mass present in a unit volume** of a substance.

$$\text{Density} = \text{Mass} / \text{Volume}$$



Cover D  $\rightarrow D = M \div V$

Cover M  $\rightarrow M = D \times V$

Cover V  $\rightarrow V = M \div D$

M = mass, D = density, V = volume

Fig. 9: Formula triangle - cover what you want to find

**Facts about density**

- Density is **independent of the shape or size** of the object. A big iron block and a small iron nail have the same density.
- Density **depends on temperature and pressure**.
- **Pressure** mainly affects the density of **gases**; its effect on solids and liquids is negligible.

**Units of density**

| Quantity | SI unit                       | Other common units                                                                 |
|----------|-------------------------------|------------------------------------------------------------------------------------|
| Mass     | kilogram (kg)                 | gram (g)                                                                           |
| Volume   | cubic metre (m <sup>3</sup> ) | cm <sup>3</sup> , mL (1 mL = 1 cm <sup>3</sup> ), litre (1 L = 1 dm <sup>3</sup> ) |
| Density  | kg/m <sup>3</sup>             | g/mL, g/cm <sup>3</sup> (convenient for liquids and solids)                        |

**Conversion and handy facts**

- $1 \text{ kg/m}^3 = 1 \text{ g/L} = 1 \text{ g/1000 mL}$  (so  $1 \text{ g/mL} = 1000 \text{ kg/m}^3$ ).
- **1 mL of water** has a mass of about **1 g** at room temperature. So 10 mL water ~ 10 g; 100 mL water ~ 100 g. Density of water ~  $1 \text{ g/mL} = 1 \text{ g/cm}^3 = 1000 \text{ kg/m}^3$ .

**Solved examples**

**Ex 1.** An aluminium block has mass 27 g and volume 10 cm<sup>3</sup>. Find its density.

**Sol.** Density =  $27 \text{ g} / 10 \text{ cm}^3 = 2.7 \text{ g/cm}^3$ .

**Ex 2.** A 1-litre packet of oil has a mass of 910 g. Is the oil denser than water?

**Sol.** 1 L = 1000 mL, so density =  $910 \text{ g} / 1000 \text{ mL} = 0.91 \text{ g/mL}$ , which is **less than 1 g/mL**. So oil is **less dense** than water and floats on it.

**Ex 3.** A steel block has a mass of 800 g and a density of 8 g/cm<sup>3</sup>. Find its volume.

**Sol.** Volume = Mass / Density =  $800 / 8 = 100 \text{ cm}^3$ .

**Relative density**

Aluminium ( $2.7 \text{ g/cm}^3$ ) is **2.7 times denser than water**. We say its **relative density** with respect to water is 2.7.

Relative density = Density of the substance / Density of water (at that temperature)

It is a **pure number** - it has **no unit**. If relative density is **less than 1** the substance is less dense than water (generally floats); if more than 1, it is denser (generally sinks).

| Material               | Approx. density ( $\text{g/cm}^3$ ) | In water    |
|------------------------|-------------------------------------|-------------|
| Air (room temperature) | 0.0012                              | Rises (gas) |
| Cooking oil            | 0.91                                | Floats      |
| Ice                    | 0.92                                | Floats      |
| Water                  | 1.0                                 | -           |
| Aluminium              | 2.7                                 | Sinks       |
| Iron                   | 7.9                                 | Sinks       |
| Mercury                | 13.6                                | Sinks       |

(Oil, aluminium and iron values are from the chapter; others are standard approximate values added for comparison.)

**Dekhe Kya Seekha Tumne? - Density basics**

**Q1. Which is denser - 1 kg of cotton or 1 kg of iron? Which has the larger volume?**

**Ans.** Iron is denser (more mass in each unit volume). 1 kg of **cotton** has the larger volume, since it is much less dense.

**Q2. Does cutting a block of iron into two halves change its density?**

**Ans.** No. Density does not depend on size or shape; it remains the same.

**Q3. A packet says "1 litre, 910 g". What does this tell about the oil?**

**Ans.** Its density is  $0.91 \text{ g/mL}$ , which is less than water, so the oil is lighter than water and floats.

**Q4. Why is relative density written without units?**

**Ans.** It is a ratio of two densities, so the units cancel out.

**Q5. Express the density of water in  $\text{kg/m}^3$ .**

**Ans.**  $1 \text{ g/cm}^3 = 1000 \text{ kg/m}^3$ , so water  $\sim 1000 \text{ kg/m}^3$ .

### 9.5.1 Determining Density: Measuring Mass and Volume

#### How to measure mass?

**Mass** is the quantity of matter present in an object. It is measured with a **balance** (shopkeepers use various types; here we use a **digital weighing balance**).

#### Activity 9.3 - Let us measure mass

- Switch ON the digital balance; it should read **zero**. If not, press the **tare / reset** button.
- Place a dry, clean **watch glass** (or butter paper) on the pan, then press **tare** to reset to zero.
- Carefully place the solid (e.g. a stone) on the watch glass. The display gives the **mass** (say **16.400 g**).
- For a **liquid**, replace the watch glass with a **beaker**, tare, and pour in the liquid.

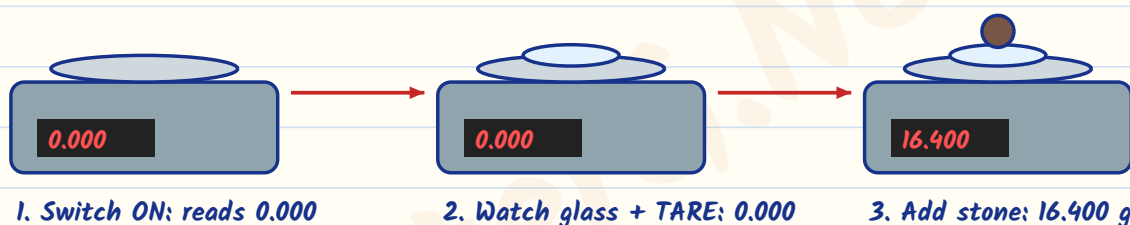


Fig. 10: Measuring the mass of a stone using a digital balance

#### A step further - mass vs weight

In daily life we use "mass" and "weight" as the same word, but in science they differ:

|            | Mass                                   | Weight                                                             |
|------------|----------------------------------------|--------------------------------------------------------------------|
| Meaning    | Quantity of matter in an object        | Force with which the Earth attracts the object                     |
| Unit       | gram (g), kilogram (kg)                | newton (N)                                                         |
| Instrument | Two-pan balance measures mass directly | Most balances actually measure weight but show readings in g or kg |

#### How to measure volume?

- **Volume** is the space occupied by an object. SI unit: **cubic metre ( $m^3$ )** (volume of a cube of side 1 m).
- Smaller volumes:  **$dm^3$**  or  **$cm^3$**  ( $1\text{ cm}^3 = 1\text{ cc}$ ). For liquids: **litre (L)** =  $1\text{ dm}^3$  and **millilitre (mL)** =  $1\text{ cm}^3$ . A buttermilk pack of 200 mL holds  $200\text{ cm}^3$  of liquid.
- A **measuring cylinder** is a narrow transparent cylindrical container (open at one end) with markings that show the volume of liquid. Available sizes: 5, 10, 25, 50, 100, 250 mL...

**Activity 9.4 - How accurately can a measuring cylinder measure?**

- **Maximum volume** = the highest mark (e.g. 100 mL).
- **Smallest volume it can read** (least count) = (difference between two big marks) / (number of small divisions between them).
- Example (Fig. 9.16): between 10 mL and 20 mL the difference is 10 mL and there are 10 divisions, so least count =  $10 / 10 = 1 \text{ mL}$ .

| Capacity of cylinder | Smallest volume it can read (usual) | Good for                           |
|----------------------|-------------------------------------|------------------------------------|
| 10 mL or 25 mL       | 0.1 mL                              | Small, accurate volumes            |
| 100 mL               | 1 mL                                | Everyday lab work (best for 70 mL) |
| 250 mL               | 2 mL                                | Larger volumes, less accuracy      |
| 500 mL               | 5 mL                                | Large volumes, least accurate      |

**Which cylinder to choose to measure 70 mL?**

- **50 mL cylinder**: cannot do it in one step ( $50 + 20$  needs two steps - inconvenient).
- **250 / 500 mL cylinder**: one step, but the smallest reading (2 mL / 5 mL) is bigger, so accuracy falls.
- **100 mL cylinder** = best choice: one step and a small least count (1 mL).

**Why are measuring cylinders tall and narrow, not wide like a beaker?**

In a narrow tube a small change in volume makes a **large change in height**, so the level can be read **more accurately**. In a wide beaker the level would rise only a little, making accurate reading difficult.

**Activity 9.5 - measure 50 mL of water correctly**

- Place a clean, dry cylinder on a **flat surface**; pour water slowly up to the mark; fine-tune with a **dropper**.
- The water surface is curved - this curved surface is called the **meniscus**.
- Keep your **eyes level** with the meniscus. For water/colourless liquids read the **bottom** of the meniscus; for **coloured liquids** read the **top** of the meniscus.

WRONG

CORRECT: eye level

WRONG

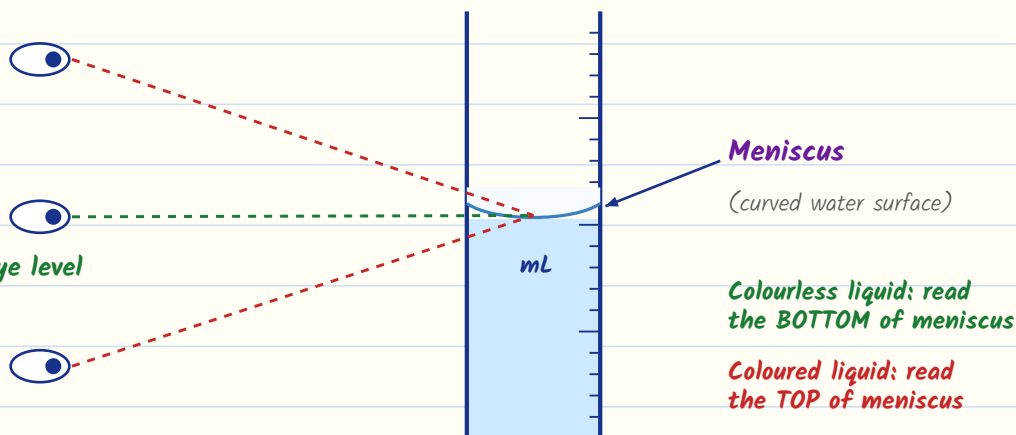


Fig. 11: Reading a measuring cylinder correctly

### Volume of regular solids (Activity 9.6)

#### Cuboid shape

Measure **length (l)**, **width (w)**, **height (h)** with a scale.  $\text{Volume} = l \times w \times h$

Notebook:  $25 \text{ cm} \times 18 \text{ cm} \times 2 \text{ cm} = 900 \text{ cm}^3$ .

### Volume of irregular solids - displacement method (Activity 9.7)

#### Let us measure the volume of a stone

- Fill a measuring cylinder with water to a mark (say **50 mL**) and record it as **A**.
- Tie the object with a thread and **lower it slowly** into the water; the level rises.
- Record the new level **B** (say **55 mL**). **Volume of the object = B - A**.

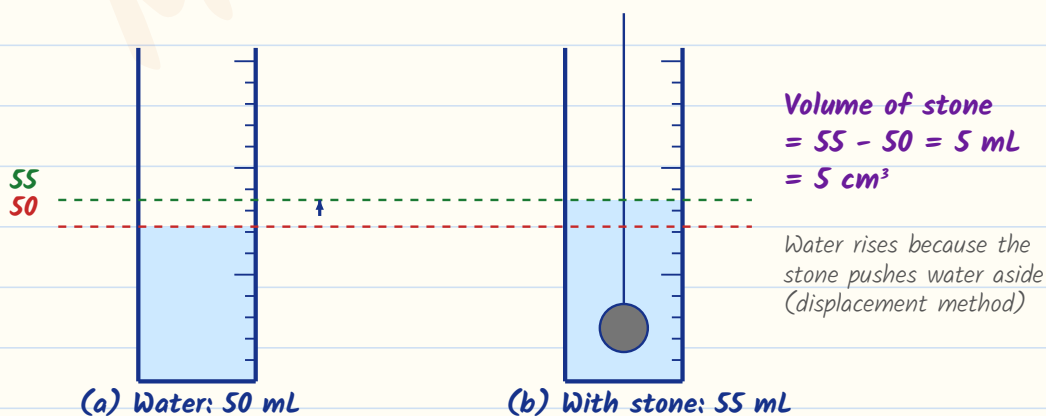


Fig. 12: Volume of an irregular solid by displacement

| S.No. | Object    | Initial volume A (mL) | Final volume B (mL) | Water displaced B - A (mL) | Volume of object (cm³) |
|-------|-----------|-----------------------|---------------------|----------------------------|------------------------|
| 1     | Stone     | 50                    | 55                  | 5                          | 5                      |
| 2     | Metal key | (your reading)        |                     |                            |                        |
| 3     | Any other | (your reading)        |                     |                            |                        |

**Let us calculate the density of the stone**

$$\text{Density} = \text{Mass} / \text{Volume} = 16.400 \text{ g} / 5 \text{ cm}^3 = 3.28 \text{ g/cm}^3.$$

Since 3.28 is more than 1 g/cm<sup>3</sup> (density of water), the stone **sinks** in water.

**Kuch Mazedaar Questions - Measuring mass and volume**

**Q1. Why do we press the "tare" button after placing the watch glass on the balance?**

**Ans.** Taring sets the display to zero with the watch glass on it, so the reading afterwards is only the mass of the object placed on the glass.

**Q2. A measuring cylinder shows 40 mL at the 4th big mark, and between 40 mL and 50 mL there are 5 small divisions. What is its least count?**

**Ans.** 10 mL / 5 divisions = 2 mL.

**Q3. Why do we read the bottom of the meniscus for water but the top for milk-like coloured liquids?**

**Ans.** For colourless liquids the bottom of the curve is clearly visible; for coloured/opaque liquids the bottom cannot be seen clearly, so the top edge is read.

**Q4. A cuboid box is 10 cm × 5 cm × 4 cm and has a mass of 400 g. Find its density.**

**Ans.**  $V = 10 \times 5 \times 4 = 200 \text{ cm}^3$ . Density =  $400/200 = 2 \text{ g/cm}^3$ .

**Q5. Water level rises from 60 mL to 78 mL when a metal piece (mass 144 g) is dipped in. Find the density.**

**Ans.** Volume =  $78 - 60 = 18 \text{ cm}^3$ . Density =  $144/18 = 8 \text{ g/cm}^3$ .

**9.5.2 Effect of Temperature on Density**

- Generally, density decreases with heating and increases with cooling.
- Reason (particulate nature of matter): on heating, particles move apart and spread - volume increases but mass does not change. Since Density = Mass / Volume, the density decreases.

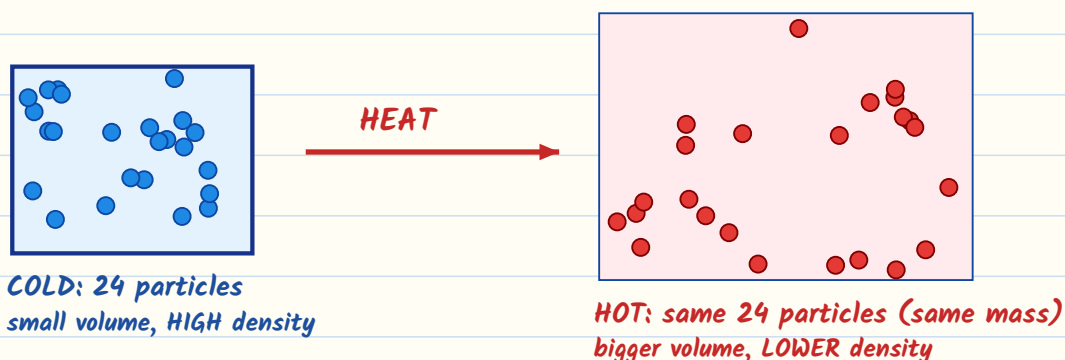


Fig. 13: Heating increases volume, so density decreases

**Applications**

- **Hot air rises** because it is **less dense** than the cool air around it.
- **Hot-air balloons** work on the same principle: the air inside is heated, becomes less dense and the balloon rises.
- This is true for solids, liquids and gases (gases show the largest effect).

**Let us dig deeper - layers of the Earth**

Earth has layers: **crust, upper mantle, lower mantle, outer core (liquid), inner core (solid)**. The **crust is the lightest** and **density increases towards the centre**, because pressure and temperature rise deep inside, making the material heavier and more compact.

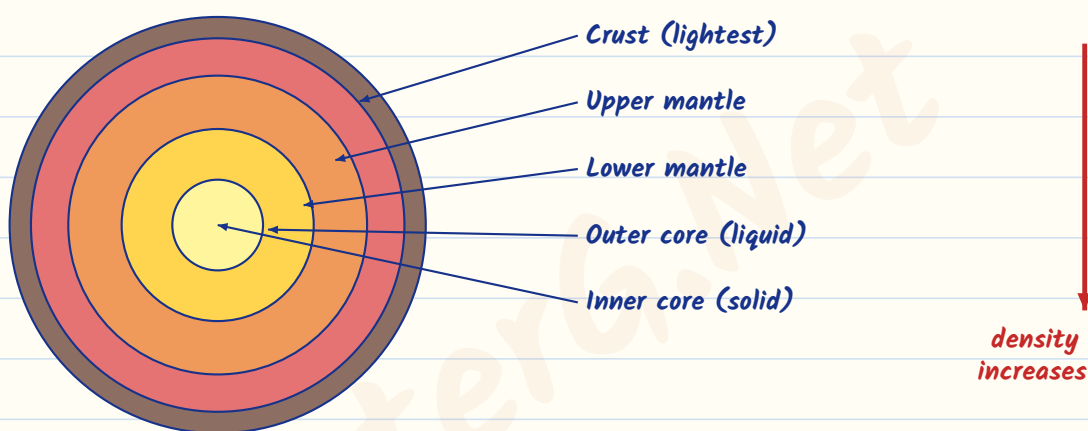


Fig. 14: Layers of the Earth - density increases as we go deeper

**9.5.3 Effect of Pressure on Density**

| State of matter | Effect of increasing pressure              | Reason                                                        |
|-----------------|--------------------------------------------|---------------------------------------------------------------|
| Gas             | Volume decreases, density <b>increases</b> | Particles are far apart and get pushed closer                 |
| Liquid          | Very small effect                          | Nearly incompressible                                         |
| Solid           | Negligible change                          | Particles already very close; even less affected than liquids |

**Ever heard of... why ice floats on water**

- Water has a special property: its **density is highest at 4 °C**.
- When water cools and turns to ice at **0 °C**, its particles arrange in a way that takes **more space** (expansion). Same mass, bigger volume, so **density decreases**: ice is **lighter than liquid water** and floats.
- **Importance**: in cold regions a layer of ice forms on top of lakes and oceans and keeps the water below **warm enough** for fish and other creatures to survive.

**Ever heard of... bamboo rafts**

In ancient times, before large ships, people used **bamboo and wooden logs** as rafts and boats to travel across rivers and seas. Bamboo is **light, hollow and floats easily**. Even today traditional bamboo/wooden boats are used in some regions for transport and as tourist attractions.

**Think like a scientist - the egg experiment**

A raw egg **sinks** in a tumbler of tap water because the egg is **denser** than water. How can you make it float?

**Answer:** dissolve salt in the water and stir. The salt solution becomes **denser than the egg** and the egg floats. (Adding more salt makes it float higher.)

**Dekhe Kya Seekha Tumne? - Density and its changes****Q1. Why does hot air rise?**

**Ans.** On heating, air expands (volume increases, mass same), so it becomes less dense than the surrounding cool air and rises.

**Q2. Why does the density of a gas increase when it is compressed?**

**Ans.** Pressure pushes gas particles closer, so the same mass occupies a smaller volume.

**Q3. Why does ice float? Why is that important?**

**Ans.** When water freezes it expands, so ice is less dense than water. A floating ice layer keeps the water below warmer, helping fish survive in cold weather.

**Q4. Which has more effect on the density of a solid - heating or compression?**

**Ans.** Heating (small but noticeable). Pressure has a negligible effect on solids.

**Q5. Why is the Earth's crust the lightest layer?**

**Ans.** Density increases toward the centre because pressure and temperature increase; the outermost layer has the least density.

## Snapshots – Quick Revision Sheet

### Learn these by heart!

- A **solution** = uniform mixture of two or more substances.
- Solid in liquid: **solid** = **solute**, **liquid** = **solvent**. Two liquids: **smaller amount** = **solute**, larger = **solvent**.
- **Saturated**: no more solute dissolves at that temperature. **Unsaturated**: more solute can still dissolve.
- **Solubility** = maximum amount of solute that dissolves in a fixed quantity (100 mL) of solvent at a particular temperature.
- Temperature up: solubility of **solids increases**, of **gases decreases**.
- **Mass** = amount of matter; **volume** = space occupied. Balance measures mass; measuring cylinder measures volume.
- **Density** = **Mass / Volume**. SI unit  $\text{kg/m}^3$ ; also  $\text{g/mL}$ ,  $\text{g/cm}^3$ .
- Density generally **decreases** with a rise in temperature; pressure affects density differently in solids, liquids and gases.

| Quantity                  | Formula / rule                                            | Unit                                              |
|---------------------------|-----------------------------------------------------------|---------------------------------------------------|
| Density                   | Mass / Volume                                             | $\text{kg/m}^3$ , $\text{g/cm}^3$ , $\text{g/mL}$ |
| Relative density          | Density of substance / density of water                   | No unit                                           |
| Volume of cuboid          | $l \times w \times h$                                     | $\text{cm}^3$ , $\text{m}^3$                      |
| Volume of irregular solid | Final level - initial level of water                      | $\text{mL} = \text{cm}^3$                         |
| Least count of cylinder   | Difference between two big marks / divisions between them | $\text{mL}$                                       |

### Memory tricks

- **Solute Small** (when liquids mix) - solvent is the Sea (bigger amount).
- **Hot** → **solids dissolve MORE**, **gases dissolve LESS**. (Think: hot chai takes more sugar; hot soda goes flat.)
- **Dense** = **Dabba packed**: more mass packed in the same space.
- **Hotter** = **lighter** (density falls) - that is why hot air balloons fly.

### Discover, Design and Debate + Our Scientific Heritage

- **Dead Sea project:** The Dead Sea is so **extremely salty** (a very concentrated salt solution) that almost no aquatic life can survive there, and swimmers float easily because the water is very dense. Look for other very salty lakes (for example the Great Salt Lake in the USA, or Sambhar Lake in Rajasthan).
- **Salt in different solvents:** compare how well common salt dissolves in **water, vinegar and oil**. Expected: dissolves well in water, somewhat in vinegar (it is mostly water), almost not in oil.
- **Debate:** "Is water truly the most versatile solvent?" - think about how many substances water dissolves, its role in our body, cooking, medicines and industry.

#### Our scientific heritage - Ningel salt, Manipur

In Ningel village (Thoubal district, Manipur) salt is still made by **traditional methods**. Salty water is drawn from **salt wells** (one lined with a 100-year-old tree trunk). Mostly women collect the salt solution and **boil it in large metal pans** over firewood. As the **water evaporates**, **salt crystals form**; these are shaped into round **salt cakes** using banana leaves and wrapped in a traditional cloth (phanek). Salt cakes are believed to have some medicinal value. This is a living example of **solute left behind when solvent evaporates**.

### NCERT Exercise - Keep the Curiosity Alive (Solved)

Q1. State whether True [T] or False [F]. Correct the false statements.

(i) Oxygen gas is more soluble in hot water rather than in cold water.

**Ans. False.** Oxygen gas is more soluble in **cold** water than in hot water.

(ii) A mixture of sand and water is a solution.

**Ans. False.** It is a **non-uniform mixture**; a solution is a uniform mixture.

(iii) The amount of space occupied by any object is called its mass.

**Ans. False.** The amount of space occupied is its **volume**; mass is the amount of matter.

(iv) An unsaturated solution has more solute dissolved than a saturated solution.

**Ans. False.** A **saturated** solution has the maximum solute dissolved; an unsaturated solution has less and can still dissolve more.

(v) The presence of different gases in the atmosphere is also a uniform mixture.

**Ans. True.**

Q2. Fill in the blanks.

(i) The volume of a solid can be measured by displacement, where the solid is \_\_\_\_\_ in water and the \_\_\_\_\_ in water level is measured.

**Ans. immersed (completely dipped); rise.**

(ii) The maximum amount of \_\_\_\_\_ dissolved in \_\_\_\_\_ at a particular temperature is called solubility.

**Ans. solute; solvent (a fixed quantity of solvent).**

(iii) Generally, the density \_\_\_\_\_ with increase in temperature.

Ans. decreases.

(iv) The solution in which glucose has completely dissolved in water and no more can dissolve is a \_\_\_\_\_ solution of glucose.

Ans. saturated.

Q3. Oil poured into a glass of water floats on top. What does this tell you?

Ans. (ii) Water is denser than oil.

Q4. A stone sculpture weighs 225 g and has a volume of 90 cm<sup>3</sup>. Find its density; will it float or sink?

Ans. Density =  $225 / 90 = 2.5 \text{ g/cm}^3$ . This is more than the density of water ( $1 \text{ g/cm}^3$ ), so it will sink.

Q5. Which is the most appropriate statement? Why are the others not appropriate?

Ans. (iii) No more solute can be dissolved into the saturated solution at that temperature. (i) is wrong - a saturated solution cannot dissolve more at that temperature. (ii) is wrong - it is the saturated solution that has the maximum solute. (iv) is wrong - saturated solutions can form at any temperature (the amount needed to saturate changes with temperature).

Q6. A bottle of 2 litres has 500 mL water poured in. How much more can it hold?

Ans.  $2 \text{ L} = 2000 \text{ mL}$ .  $2000 - 500 = 1500 \text{ mL}$  (1.5 L).

Q7. Mass 400 g, volume 40 cm<sup>3</sup>. Density?

Ans. Density =  $400 / 40 = 10 \text{ g/cm}^3$ .

Q8. Why does the unpeeled orange float while the peeled one sinks?

Ans. The orange peel has many tiny air pockets that trap air, so the unpeeled orange has a lower overall density than water and floats. After peeling, the fruit alone is denser than water and sinks.

Q9. Object A: 200 g, 40 cm<sup>3</sup>. Object B: 240 g, 60 cm<sup>3</sup>. Which is denser?

Ans. A:  $200/40 = 5 \text{ g/cm}^3$ ; B:  $240/60 = 4 \text{ g/cm}^3$ . So A is denser.

Q10. Reema moulds 120 g clay into a cube of volume 60 cm<sup>3</sup>, then flattens it. What happens to the density?

Ans. Density =  $120/60 = 2 \text{ g/cm}^3$ . It stays the same because mass and volume do not change; density does not depend on shape.

Q11. Iron block mass 600 g, density 7.9 g/cm<sup>3</sup>. Volume?

Ans. Volume = Mass / Density =  $600 / 7.9 = \text{about } 75.9 \text{ cm}^3$  (approximately 76 cm<sup>3</sup>).

Q12. In the setup of Fig. 9.26, the water level in the glass tube rises when the test tube is placed in hot water (~70 °C). How does it affect the density?

Ans. On heating, the water expands - its volume increases while the mass stays the same - so its density decreases.

**Practice Time – Thoda Aur Practice!****A. Multiple choice questions**

1. A uniform mixture of two or more substances is called a: (a) suspension (b) solution (c) non-uniform mixture (d) solvent
2. In a solution of sugar in water, the solvent is: (a) sugar (b) water (c) both (d) none
3. A solution that cannot dissolve any more solute at a given temperature is: (a) dilute (b) unsaturated (c) saturated (d) uniform
4. With a rise in temperature the solubility of oxygen in water generally: (a) increases (b) decreases (c) stays same (d) becomes zero
5. The SI unit of density is: (a) g/mL (b)  $\text{g/cm}^3$  (c)  $\text{kg/m}^3$  (d) kg/L
6. A body has mass 50 g and volume  $25 \text{ cm}^3$ . Its density is: (a)  $0.5 \text{ g/cm}^3$  (b)  $2 \text{ g/cm}^3$  (c)  $25 \text{ g/cm}^3$  (d)  $75 \text{ g/cm}^3$
7. Which of the following is a non-uniform mixture? (a) salt in water (b) air (c) sawdust in water (d) sugar in water
8. The correct way to read water level in a measuring cylinder is to keep the eye: (a) above the meniscus (b) below the meniscus (c) at the level of the bottom of the meniscus (d) anywhere
9. Density of a substance generally \_\_\_\_\_ on heating: (a) increases (b) decreases (c) remains the same (d) first increases then decreases
10. Ice floats on water because: (a) ice is heavier (b) ice is less dense than water (c) water is hot (d) ice is hollow
11. The volume of water displaced by an object dipped in a cylinder gives: (a) its mass (b) its density (c) its volume (d) its weight
12. The relative density of a substance is 4. Its density in  $\text{g/cm}^3$  is: (a) 0.25 (b) 1 (c) 4 (d) 4000

**B. Fill in the blanks**

1. The substance present in smaller amount in a solution of two liquids is called the \_\_\_\_\_.
2. A solution containing more solute is called a \_\_\_\_\_ solution.
3. The curved surface of a liquid in a measuring cylinder is called the \_\_\_\_\_.
4. Density = \_\_\_\_\_ / \_\_\_\_\_.
5. Water has maximum density at \_\_\_\_\_  $^{\circ}\text{C}$ .
6. The mass of 1 mL of water is about \_\_\_\_\_ g.

**C. True or False**

1. Density of a body changes when its shape changes.
2. Chashni has more sugar than water, so sugar is the solvent.
3. Pressure has a large effect on the density of solids.
4. Hot air is less dense than cool air.
5. A saturated solution at  $30^{\circ}\text{C}$  may become unsaturated at  $60^{\circ}\text{C}$ .

**D. Assertion - Reason**

Options: (A) both true, R explains A; (B) both true, R does not explain A; (C) A true, R false; (D) A false, R true.

1. **A:** Fish can die in a pond during a heat wave. **R:** The solubility of oxygen in water decreases when water warms up.
2. **A:** A hot-air balloon rises. **R:** Heating air makes it denser than the surrounding air.
3. **A:** Ice floats on water. **R:** Ice has a lower density than liquid water.

**E. Numericals**

1. A metal cube of side 5 cm has a mass of 1000 g. Find its density in  $\text{g/cm}^3$  and in  $\text{kg/m}^3$ . Will it sink in water?
2. A measuring cylinder has 40 mL water. When a stone is dipped, the level reaches 62 mL. If the stone has a mass of 66 g, find its density.
3. Find the mass of 250 mL of a liquid of density 0.8 g/mL.
4. The density of a substance is  $13.6 \text{ g/cm}^3$ . What is its relative density? Will it float on water?
5. A solution has 15 g salt in 150 mL water, another has 20 g salt in 100 mL water. Which is more concentrated?

**F. Short and long answers**

1. Differentiate between uniform and non-uniform mixtures with two examples each.
2. Explain with an activity how temperature affects the solubility of a solid.
3. Why does the solubility of gases decrease with temperature? Mention one effect on aquatic life.
4. Describe the method of finding the volume of an irregular solid. Why is a narrow cylinder used?
5. Explain why ice floats on water and why this is useful for aquatic life.
6. How would you choose a measuring cylinder for measuring 70 mL of water?

**G. Zara Dimaag Lagao (HOTS)**

1. A cup of tea has sugar lying undissolved at the bottom. Give two ways to dissolve it. Which of these keeps the sweetness the same?
2. Two beakers contain equal amounts of water at  $20^\circ\text{C}$  and  $60^\circ\text{C}$ . You dissolve baking soda in both until it stops dissolving. In which will you add more? What does this tell about solubility?
3. Can a solid float in water but sink in oil? Explain using density (density of oil =  $0.91 \text{ g/cm}^3$ ).
4. Why does a hot-air balloon rise when the air inside it is heated?

**Answer Key - Practice Time**

| Section       | Answers                                                                                                                 |
|---------------|-------------------------------------------------------------------------------------------------------------------------|
| A. MCQ        | 1-(b); 2-(b); 3-(c); 4-(b); 5-(c); 6-(b) [ $50/25 = 2$ ]; 7-(c); 8-(c); 9-(b); 10-(b); 11-(c); 12-(c)                   |
| B. Blanks     | 1. solute; 2. concentrated; 3. meniscus; 4. mass, volume; 5. $4^\circ\text{C}$ ; 6. 1                                   |
| C. True/False | 1-False (density does not depend on shape); 2-False (water is the solvent); 3-False (negligible effect); 4-True; 5-True |

| Section                | Answers                                                                                                                                                                                                                                                                                                                                        |
|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| D.<br>Assertion-Reason | 1-(A); 2-(D) [heating makes air LESS dense]; 3-(A)                                                                                                                                                                                                                                                                                             |
| E. Numericals          | 1. Volume $125 \text{ cm}^3$ , density $8 \text{ g/cm}^3 = 8000 \text{ kg/m}^3$ , sinks; 2. Volume $22 \text{ cm}^3$ , density $3 \text{ g/cm}^3$ ; 3. mass = $0.8 \times 250 = 200 \text{ g}$ ; 4. relative density 13.6, it sinks; 5. First: $15/150 = 0.1 \text{ g/mL}$ ; second: $20/100 = 0.2 \text{ g/mL}$ - second is more concentrated |

**Hints for Sections F and G**

- **G1:** Heat the tea / stir more / add more tea. Heating or stirring keeps the same sweetness only if you do not add extra liquid (adding more tea makes it more dilute).
- **G2:** More dissolves at  $60^\circ\text{C}$  - for most solids solubility increases with temperature.
- **G3:** Yes. Oil ( $0.91 \text{ g/cm}^3$ ) is less dense than water ( $1 \text{ g/cm}^3$ ). A solid with density between  $0.91$  and  $1 \text{ g/cm}^3$  floats in water but sinks in oil.
- **G4:** Heated air expands, its density falls below that of the surrounding cool air, so the balloon rises.

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